

What is Claimed:

1. A dispersion, comprising:
 - an aqueous medium;
 - carbon nanotubes; and
 - at least one surfactant comprising an aromatic group, an alkyl group having from about 4 to about 30 carbon atoms, and a charged head group.
2. The dispersion according to claim 1, wherein the carbon nanotubes comprise single-wall carbon nanotubes, multi-wall carbon nanotubes, armchair carbon nanotubes, zigzag carbon nanotubes, chiral carbon nanotubes, carbon nanofibers, carbon nanotoroids, branched carbon nanotubes, or any combination thereof.
3. The dispersion according to claim 1, wherein said surfactant is capable of non-covalently adhering to said carbon nanotubes.
4. The dispersion according to claim 1, wherein said alkyl group is an alkyl chain.
5. The dispersion according to claim 1, wherein said alkyl group has from about 6 to about 20 carbon atoms.
6. The dispersion according to claim 1, wherein said alkyl group has from about 8 to about 16 carbon atoms.
7. The dispersion according to claim 1, wherein said alkyl group has from about 10 to about 14 carbon atoms.
8. The dispersion according to claim 1, wherein said aromatic group is disposed between the alkyl group and the head group.
9. The dispersion according to claim 1, wherein said aromatic group is capable of π -like stacking onto the surface of the carbon nanotubes.

10. The dispersion according to claim 1, wherein said aromatic group comprises a carbocyclic aromatic ring, a heterocyclic aromatic ring, or any combination thereof.
11. The dispersion according to claim 1, wherein said aromatic group comprises at least one benzene rings.
12. The dispersion according to claim 1, wherein said charged head group comprises a sulfate group, a sulfonate group, ammonia, an amine, an ammonium group, or any combination thereof.
13. The dispersion according to claim 1, wherein said surfactant comprises said alkyl group bonded to the aromatic group, said aromatic group being further bonded to the head group.
14. The dispersion according to claim 1, wherein a plurality of said alkyl groups are bonded to the aromatic group.
15. The dispersion according to claim 1, wherein said surfactant comprises an alkaline salt of a C_n alkyl benzene sulfonate, where n is between about 8 and about 16.
16. The dispersion according to claim 14, wherein said alkaline salt comprises a counterion selected from the Group IA elements or any combination thereof.
17. The dispersion according to claim 14, wherein said counterion is sodium, potassium, or any combination thereof.
18. The dispersion according to claim 1, wherein said surfactant comprises sodium hexylbenzene sulfonate, sodium octylbenzene sulfonate, sodium dodecylbenzene sulfonate, sodium hexadecylbenzene sulfonate, or any combination thereof.
19. The dispersion according to claim 1, wherein the concentration of dispersed carbon nanotubes is between about 0.001 mg/ml and about 500 mg/ml.
20. The dispersion according to claim 19, wherein the concentration of dispersed carbon nanotubes is at least about 0.5 mg/ml.

21. The dispersion according to claim 19, wherein the concentration of dispersed carbon nanotubes is at most about 30 mg/ml.
22. The dispersion according to claim 1, wherein the number percentage of single SWNTs is at least about 50 percent.
23. The dispersion according to claim 1, wherein the number percentage of single SWNTs is at least about 75 percent.
24. The dispersion according to claim 1, wherein the number percentage of single SWNTs is at least about 90 percent.
25. The dispersion according to claim 1, wherein the mean length of single SWNTs is at least about 120 nm.
26. The dispersion according to claim 1, wherein the mean length of single SWNTs is at least about 300 nm.
27. The dispersion according to claim 26, wherein the number percentage of single SWNTs is at least about 50 percent.
28. The dispersion according to claim 1, wherein the mean length of single SWNTs is at least about 500 nm.
29. The dispersion according to claim 1, wherein the weight ratio of carbon nanotubes to surfactant is in the range of from about 5 : 1 to about 1 : 10.
30. The dispersion according to claim 1, wherein the carbon nanotubes are charge stabilized.
31. The dispersion according to claim 1, wherein said surfactant comprises at least two alkyl groups.
32. The dispersion according to claim 1, wherein said surfactant comprises at least two aromatic groups.

33. The dispersion according to claim 1, wherein said surfactant comprises at least two charged head groups.
34. The dispersion according to claim 1, wherein said surfactant comprises at least two alkyl chains, at least two aromatic rings, at least two charged groups, or any combination thereof.
35. The dispersion according to claim 1, wherein the aqueous liquid phase comprises at least about 50 weight percent water.
36. The dispersion according to claim 1, wherein the aqueous liquid phase comprises up to about 50 weight percent of a solvent different than water.
37. A method of preparing a dispersion of carbon nanotubes, said method comprising:
mixing an aqueous medium, carbon nanotubes, and surfactant in a low-power, high-frequency bath sonicator, said surfactant comprising an alkyl group having from about 4 to about 30 carbon atoms, an aromatic group, and a charged head group.
38. The method of claim 37, wherein the mixing time in the bath sonicator is at least about two hours.
39. The method of claim 37, wherein the mixing time in the bath sonicator is at least about four hours.
40. The method of claim 37, wherein the mixing time in the bath sonicator is at least about eight hours.
41. The method of claim 37, wherein the mixing time in the bath sonicator is between about 16 and about 24 hours.
42. The method of claim 37, wherein the bath sonicator has a power in the range of from about 5 watts to about 150 watts.

43. The method of claim 37, wherein the bath sonicator has a frequency in the range of from about 20 kHz to about 75 kHz.

44. The method of claim 37, wherein said surfactant comprise an alkaline salt of a C_n alkyl benzene sulfonate, where n is between about 8 and about 16.

45. The method of claim 37, wherein the concentration of dispersed carbon nanotubes is between about 0.001 mg/ml and about 500 mg/ml.

46. The method of claim 37, wherein the concentration of dispersed carbon nanotubes is at least about 0.5 mg/ml.

47. The method of claim 37, wherein the mixing time is selected to give rise to at least about 50 number percent of the dispersed carbon nanotubes being single SWNTs.

48. The method of claim 47, wherein the mixing time is selected to give rise to the mean length of single SWNTs being at least about 300 nm.

49. The method of claim 37, wherein the mixing time is selected to give rise to the mean length of single SWNTs being at least about 500 nm.

50. The method of claim 37, wherein the weight ratio of carbon nanotubes to surfactant is in the range of from about 5 : 1 to about 1 : 10.

51. The method of claim 37, wherein the concentration of the surfactant is less than the critical micelle concentration.

52. The method of claim 37, wherein the electronic properties of the dispersed carbon nanotubes are essentially the same as the electronic properties of the carbon nanotubes prior to mixing.

53. The method of claim 37, further comprising the step of electrophoretically separating the dispersed carbon nanotubes.

54. The method of claim 53, wherein the carbon nanotubes are separated according to length, shape, or any combination thereof.

55. A composition, comprising:

carbon nanotubes; and

surfactant comprising an alkyl group having from about 4 to about 30 carbon atoms, an aromatic group, and a charged head group.

56. The composition of claim 55, wherein said surfactant is adsorbed to the exterior surface of said carbon nanotubes.

57. The composition of claim 55, wherein the composition is in the form of a powder, a film, a particle, a pellet, or any combination thereof

58. A composite, comprising:

a solid matrix; and

carbon nanotubes and surfactant dispersed within said solid matrix, said surfactant comprising an alkyl group having from about 4 to about 30 carbon atoms, an aromatic group, and a head group.

59. The composite of claim 58, wherein said solid matrix material comprises a linear polymer, a branched polymer, a crosslinked polymer, a grafted polymer, a block co-polymer, or any combination thereof.

60. The composite of claim 58, wherein the composite is in the form of a pellet, a powder, a film, a particle, or any combination thereof.

61. A method of preparing a composite, comprising:

dispersing carbon nanotubes and surfactant in a hardenable matrix precursor, said surfactant comprising an alkyl group having from about 4 to about 30 carbon atoms, an aromatic group, and a head group; and

hardening the precursor.

62. The method of claim 61, wherein hardening the precursor comprises curing the precursor with at least one of light, heat, radiation, and time.

63. The method of claim 61, wherein said hardenable matrix precursor is a polymer capable of solidifying upon cooling to a temperature being lower than its glass transition temperature, its crystalline melt transition, its order-disorder transition temperature, or any combination thereof.

64. An assembly, comprising:

a substrate; and

carbon nanotubes and surfactant adjacent to said substrate, said surfactant comprising an alkyl group having from about 4 to about 30 carbon atoms, an aromatic group, and a charged head group.

65. The assembly of claim 64, wherein the carbon nanotubes are self-assembled on said substrate.

66. The assembly of claim 64, wherein said surfactant is adsorbed to the exterior surface of said carbon nanotubes.

67. A method of assembling carbon nanotubes, comprising:

contacting a dispersion comprising an aqueous medium, carbon nanotubes and surfactant to a substrate, said surfactant comprising an alkyl group having from about 4 to about 30 carbon atoms, an aromatic group, and a charged head group.

68. The method of claim 67, wherein at least a portion of said carbon nanotubes self-assemble on said substrate.
69. Solid media for use in detecting chemical and biological substances, comprising:
a substrate for receiving chemical compounds, biological materials, or both biological materials and chemical compounds for detection, said substrate comprising carbon nanotubes and surfactant adsorbed thereon, said surfactant comprising an alkyl group having between about 6 and about 30 carbon atoms, an aromatic group, and a charged head group.
70. The solid media of claim 69, wherein said surfactant is adsorbed to the exterior surface of said carbon nanotubes.
71. The solid media of claim 69, wherein said carbon nanotubes are self-assembled on said substrate.
72. The solid media of claim 69, wherein said carbon nanotubes are capable of adsorbing protons to give rise to a detectable signal.
73. The solid media of claim 69, wherein said carbon nanotubes are chemically functionalized to adsorb specific biological or chemical substances to give rise to a detectable signal.
74. A method of preparing a nematic nanotube gel, comprising:
providing a dispersion comprising carbon nanotubes, solvent, gel precursor, and surfactant, said surfactant comprising an alkyl group having from about 4 to about 30 carbon atoms, an aromatic group, and a charged head group;
gelling at least a portion of said gel precursor to form a gel; and
subjecting the dispersion, the gel, or both the dispersion and the gel to an orienting field, said orienting field giving rise to a nematic orientation of said carbon nanotubes.

75. The method according to claim 74, wherein the orienting field comprises a pressure field, a magnetic field, a thermodynamic field, an electric field, an electromagnetic field, a shear field, a gravitational field, or any combination thereof.

76. The method of claim 74, wherein the carbon nanotubes are single-wall carbon nanotubes, multi-wall carbon nanotubes, armchair carbon nanotubes, zigzag carbon nanotubes, chiral carbon nanotubes, carbon nanofibers, carbon nanotoroids, branched carbon nanotubes, or any combination thereof.

77. The method of claim 74, wherein said surfactant adsorbs to said carbon nanotubes.

78. The method of claim 74, wherein the alkyl group has between about 10 and about 14 carbon atoms.

79. The method of claim 74, wherein said aromatic group is disposed between the alkyl group and the charged head group.

80. The method of claim 74, wherein said aromatic group is capable of π -like stacking onto the surface of the carbon nanotubes.

81. The method of claim 74, wherein said aromatic group comprises at least one carbocyclic aromatic ring, a heterocyclic aromatic ring, or any combination thereof.

82. The method of claim 74, wherein said aromatic group comprises at least one benzene ring.

83. The method of claim 74, wherein said charged head group comprises a sulfate group, a sulfonate group, an amine group, an ammonium group, or any combination thereof.

84. The method of claim 74, wherein said surfactant comprises said alkyl group bonded to the aromatic group, said aromatic group being further bonded to the head group.

85. The method of claim 84, wherein said alkyl group has between about 8 and about 16 carbon atoms, and said charged head group comprises sulfonate.

86. The method of claim 74, wherein said surfactant comprises an alkaline salt of a C_n alkyl benzene sulfonate, where n is between about 8 and about 16.
87. The method of claim 86, wherein said alkaline salt comprises at least one counterion selected from the Group IA elements.
88. The method of claim 87, wherein said counterion is sodium, potassium, or any combination thereof.
89. The method of claim 74, wherein said surfactant comprises sodium hexylbenzene sulfonate, sodium octylbenzene sulfonate, sodium dodecylbenzene sulfonate, sodium hexadecylbenzene sulfonate, or any combination thereof.
90. The method of claim 74, wherein the concentration of dispersed carbon nanotubes is between about 0.001 mg/ml and about 500 mg/ml.
91. The method of claim 90, wherein the concentration of dispersed carbon nanotubes is at least about 0.5 mg/ml.
92. The method of claim 90, wherein the concentration of dispersed carbon nanotubes is at most about 30 mg/ml.
93. The method of claim 74, wherein the number percentage of single SWNTs is at least about 50 percent.
94. The method of claim 74, wherein the number percentage of single SWNTs is at least about 75 percent.
95. The method of claim 74, wherein the number percentage of single SWNTs is at least about 90 percent.
96. The method of claim 74, wherein the mean length of single SWNTs is at least about 120 nm.

97. The method of claim 74, wherein the mean length of single SWNTs is at least about 300 nm.

98. The method of claim 26, wherein the percentage of single SWNTs is at least about 50 percent.

99. The method of claim 98, wherein the mean length of single SWNTs is at least about 500 nm.

100. The method of claim 74, wherein the weight ratio of carbon nanotubes to surfactant is in the range of from about 5 : 1 to about 1 : 10.

101. The method of claim 74, wherein the carbon nanotubes are charge stabilized in the dispersion.

102. The method of claim 74, wherein said surfactant comprise at least two alkyl chain tails.

103. The method of claim 74, wherein the solvent comprises at least about 50 weight percent water.

104. The method of claim 74, wherein the solvent comprises less than about 50 weight percent of a solvent different than water.

105. The method of claim 74, wherein the gel precursor comprises monomer, oligomer, polymer, ceramic gel precursor, or any combination thereof.

106. The method of claim 105, wherein the monomer is polymerizable via chain growth, step-growth, or any combination of chain-growth and step-growth polymerization mechanisms.

107. The method of claim 106, wherein the monomer is ethylenically-unsaturated.

108. The method of claim 107, wherein the ethylenically unsaturated monomer comprises methacrylic monomer, acrylic monomer, methacrylamide monomer, acrylamide monomer,

vinyl acetate monomer, vinyl halide monomer, diene monomer, styrenic monomer, or any combination thereof.

109. The method of claim 105, wherein the polymer gel precursor further comprises a crosslinker.

110. The method of claim 105, wherein the polymer gel precursor further comprises an initiator.

111. The method of claim 105, wherein the polymer gel precursor further comprises an accelerator.

112. The method according to claim 75, wherein the field is a thermodynamic field giving rise to a volumetric phase transition.

113. The method of claim 112, wherein the volumetric phase transition arises from a change in temperature.

114. The method of claim 112, wherein the volumetric phase transition arises from an increase in temperature.

115. The method of claim 112, wherein the volumetric phase transition arises from an incompatibility between the gel and the solvent.

116. The method of claim 115, wherein the incompatibility between the gel and the solvent arises from a decrease in a specific attractive interaction.

117. The method of claim 116, wherein the specific attractive interaction is hydrogen bonding.

118. The method of claim 112, wherein the gel is a polymer gel comprising a network, and the volumetric phase transition arises upon increasing temperature, wherein the polymer network becomes hydrophobic and solvent is expelled from the gel.

119. The method of claim 118, wherein the solvent comprises at least about 50 weight percent water.
120. The method of claim 112, further comprising removing solvent that is expelled from the gel during or after subjecting the gel to a volumetric phase transition.
121. The method of claim 112, wherein the ratio of the volume of the gel before the volumetric phase transition to the volume of the gel after the volumetric phase transition is in the range of from about 1.1 : 1 to about 50 : 1.
122. The method of claim 121, wherein the ratio is in the range of from about 4:1 to about 30:1.
123. The method of claim 74, wherein the gel becomes birefringent subsequent to subjecting said gel to the orienting field.
124. The method of claim 74, further comprising the step of micro-phase separating the dispersion into nanotube rich/gel poor and nanotube poor/gel rich phases.
125. The method of claim 124, wherein the gel is a polymer gel, and the micro-phase separating step is carried out under conditions giving rise to polymerization-induced phase separation.
126. The method of claim 75, wherein the field is a pressure field giving rise to transport of at least a portion of the solvent out of the gel.
127. The method of claim 126, wherein the gel is confined to a restricted geometry vessel.
128. The method according to claim 127, wherein the gel is confined to a capillary tube during transport of at least a portion of the solvent out of the gel.
129. The method according to claim 127, wherein the gel is confined to a capillary tube after transport of at least a portion of the solvent out of the gel.

130. The method according to claim 127, wherein the gel is confined to a capillary tube both during and after transport of at least a portion of the solvent out of the gel.
131. The method according to claim 127, wherein the gel is confined to a capillary tube.
132. The method according to claim 126, wherein the pressure field is lower than the partial pressure of the solvent in the vapor phase.
133. The method according to claim 132, wherein the pressure field is an applied vacuum.
134. The method of claim 75, wherein the field is a magnetic field having a strength between about 0.01 Tesla and about 60 Tesla.
135. The method of claim 134, wherein the viscosity of the gel while the dispersion is being subjected to the magnetic field is in the range of from about 1 centipoise to about 5000 centipoise.
136. The method of claim 135, wherein the concentration of the carbon nanotubes is in the range of from about 0.01 mg/ml to about 500 mg/ml.
137. The method of claim 74, wherein at least a portion of the carbon nanotubes align end-on-end giving rise to a carbon nanotube needle.
138. The method of claim 137, further comprising the step of removing solvent from the gel.
139. A composition, comprising carbon nanotubes, gel precursor, and surfactant, said surfactant comprising an alkyl group having from about 4 to about 30 carbon atoms, an aromatic group, and a charged head group.